Instrumentation and Control Systems

Speed Measurement

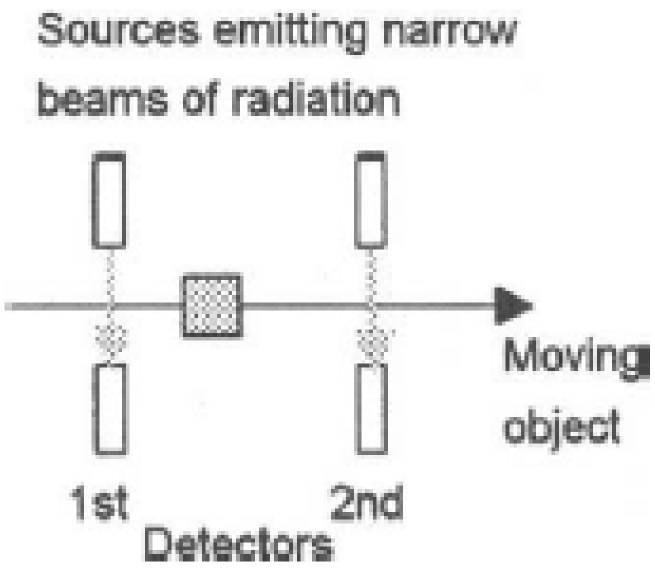
Rajiv Gandhi University of Knowledge Technologies,
Basar

Different methods for Speed measurement

- Optical methods
- Incremental encoder
- Tachogenerator
- Variable reluctance tachometer
- Hall effect sensor

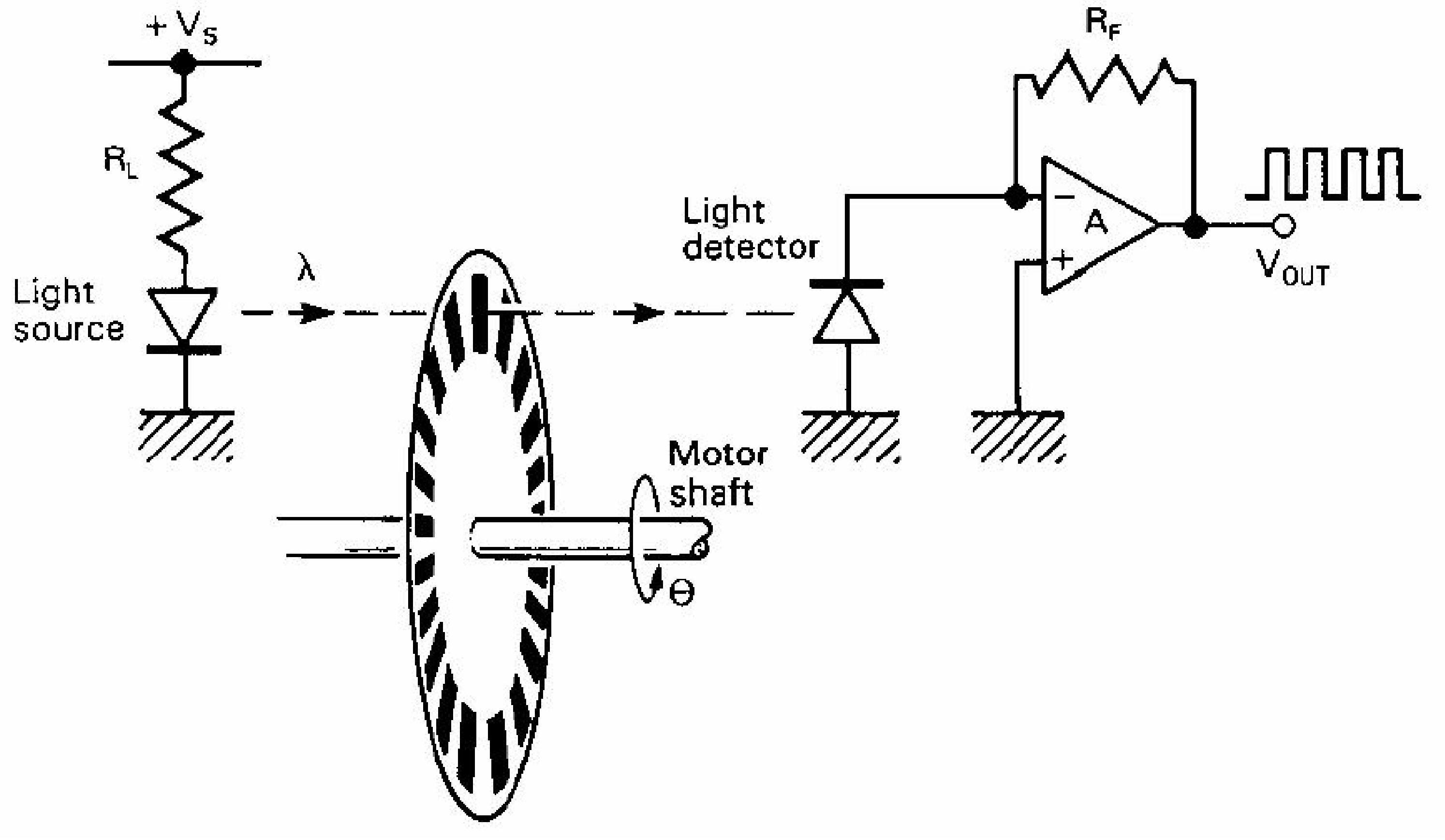
Optical method

- Linear speeds can be measured by determining the time between when the moving object breaks one beam of radiation and when it breaks a second beam some measured distance away.
- Breaking the first beam can be used to start an electronic clock and breaking the second beam to stop the clock.



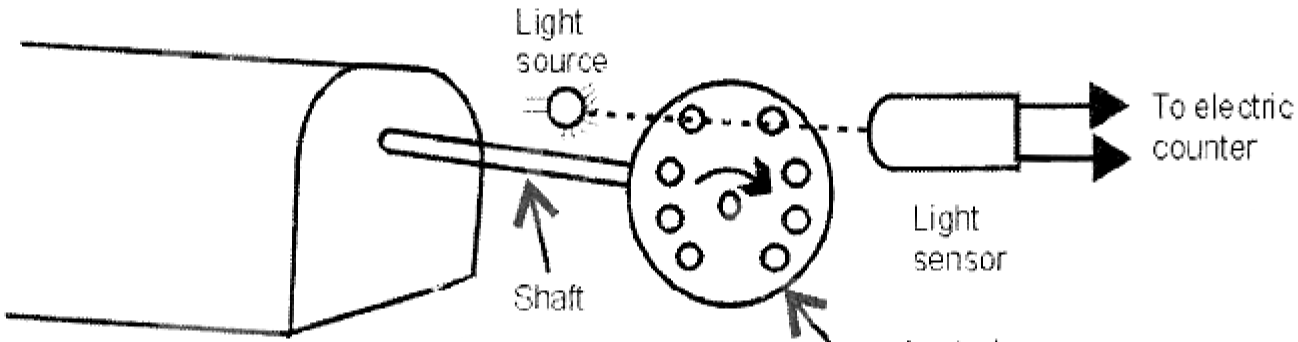
Incremental encoder

- The incremental encoder can be used for a measurement of angular speed of a rotating shaft, the number of pulses produced per second being counted.



Transmissive type photoelectric tachometer

- Slotted disc or disc with hole is mounted on a rotating shaft
- At one side of disc a light source is fixed and at the other side of the disc an on line with the light source, a photodetector is placed.
- When the opaque portion of the disc is between the source and the detector, the latter is unilluminated and produces no output
- But when a slot/hole appears, light falling on the detector produces output

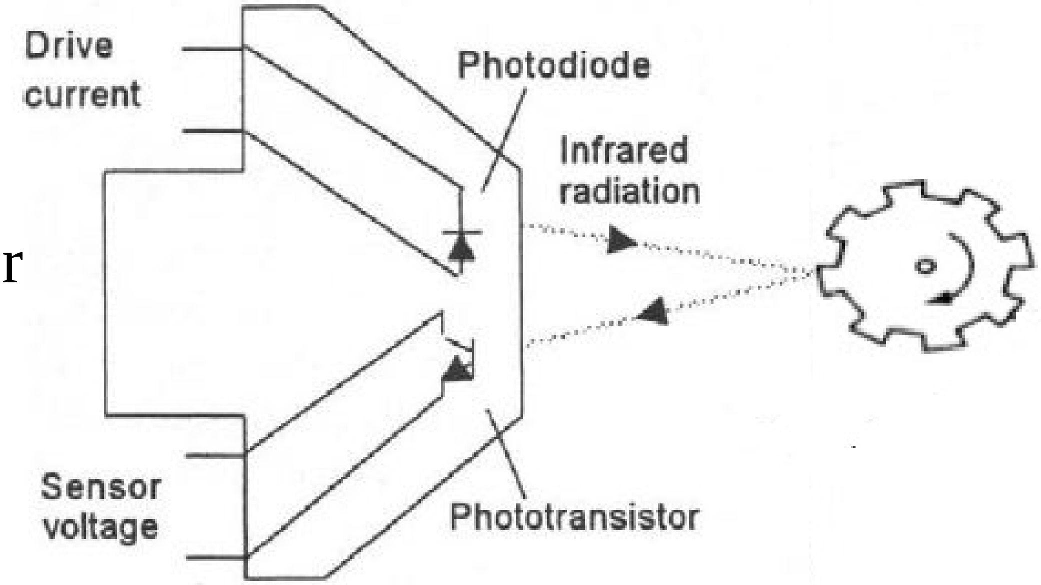


Photoelectric Tachometer

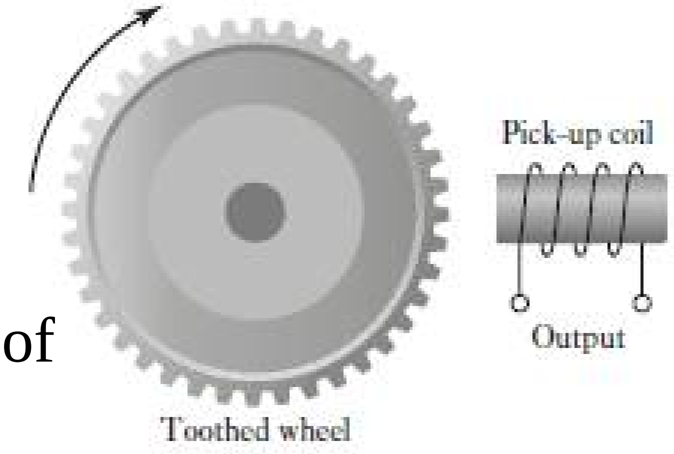
- frequency at which pulses are produced depends upon the number of hole or slots on the disc and its speed of rotation
- Pulse rate is a function of speed of rotation
- Pulse rate is measured by an electronic counter

Reflective type photo electric tachometer

- Slotted wheel or wheel with holes connected motor shaft can be used as reflector for IR radiation (invisible).
- Transmitter when applied with voltage transmits IR light
- Slotted wheel tooth reflects this light back and photodetector receives this reflected light and gives the output.
- This voltage will appear as pulses which can be further amplified to obtain pulses of sufficient amplitude which can be measured by counter or frequency to voltage converter



Tachogenerator



- It is used to measure angular velocity.
- One form, the variable reluctance tachogenerator, consists of a toothed wheel of ferromagnetic material which is attached to the rotating shaft.
- A pick-up coil is wound on a permanent magnet.
- As the wheel rotates, so the teeth move past the coil and the air gap between the coil and the ferromagnetic material changes.
- An air gap periodically changes.
- Thus the flux linked by a pick-up coil changes. The resulting cyclic change in the flux produces an alternating e.m.f. in the coil

- If the wheel contains n teeth and rotates with an angular velocity ω, then the flux change with time for the coil can be considered as

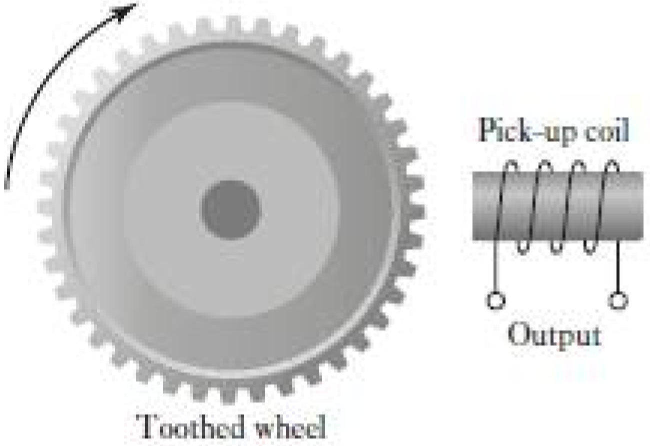
$$\phi = \phi_0 + \phi_a \cos n\omega t$$

- where ϕ_0 is the mean value of the flux and ϕ_a the amplitude of the flux variation.
- The induced e.m.f. e in the N turns of the pick-up coil = -N dϕ/dt

$$e = N\phi_a n\omega \sin n\omega t$$

- also

$$e = E_{\max} \sin n\omega t$$

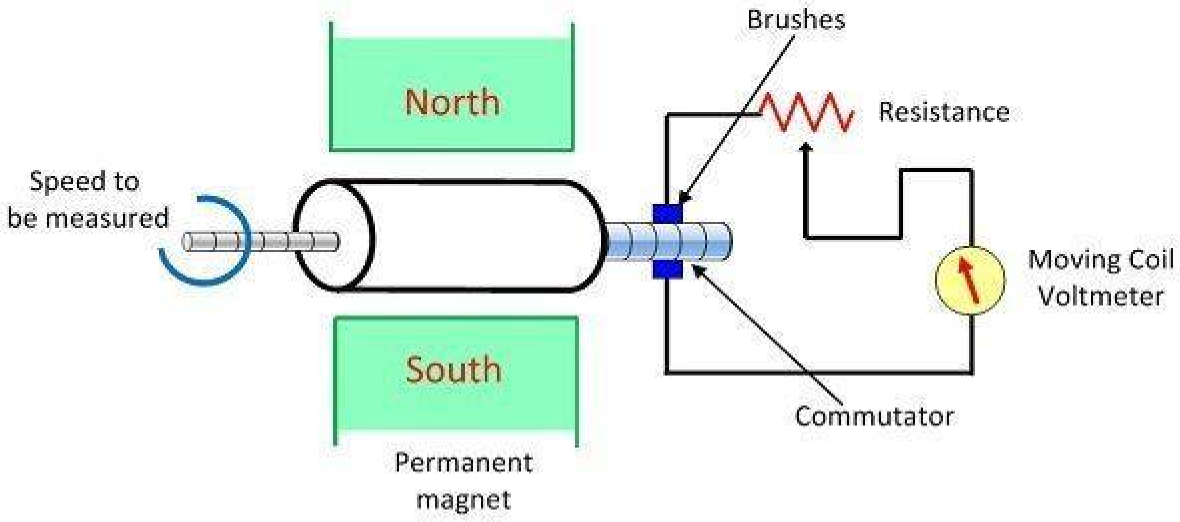


- where the maximum value of the induced e.m.f. E_{max} is $N\phi_a n\omega$ and so is a measure of the angular velocity.

- In principle ω *can be found from either the amplitude or the frequency of the* signal.
- In practice the amplitude measured by a distant recorder or indicator may be affected by loading effects and electrical interference.
- A frequency system is therefore preferred, where the number of cycles in a given time is counted to give a digital signal corresponding to the angular velocity

D.C Tachogenerators

- The armature of the D.C Tachogenerator is kept in the permanent magnetic field.
- The armature of the tachogenerator is coupled to the machine whose speed is to be measured.
- When the shaft of the machine revolves, the armature of the tachogenerator revolves in the magnetic field producing e.m.f. which is proportional to the product of the flux and speed to be measured.



- emf induces in the dc tachometer generator is given as

$$E = \frac{\emptyset PN}{60} \times \frac{z}{a}$$

- Where, E – generated voltage
  Φ – flux per poles in Weber
  P- number of poles
  N – speed in revolution per minutes
  z – the number of the conductor in armature windings.
  ɑ – number of the parallel path in the armature windings.

$$E \; \alpha \; N$$

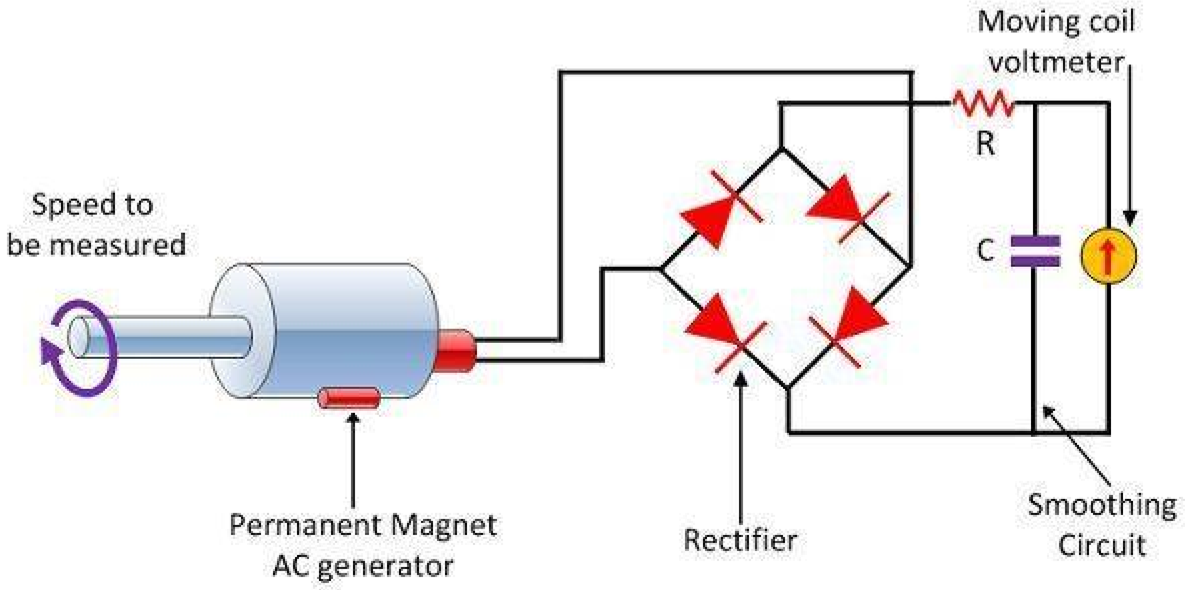
$$E = KN$$

$$K = Constant = \frac{\emptyset P}{60} \times \frac{z}{a}$$

- Now as the field of the permanent field is fixed, the e.m.f generated is proportional to the speed directly.
- The e.m.f induced is measured using moving coil voltmeter with uniform scale calibrated in speed directly.
- The series resistance is used to limit the current under output short circuit condition.
- The polarity of output voltage indicates the direction of rotation.
- The commutator collects current from armature conductors and converts internally induced a.c e.m.f into d.c (unidirectional) e.m.f. while the brushes are used to collect current from commutator and make it available to external circuitry of the d.c tachogenerator.

AC Tachometer Generator

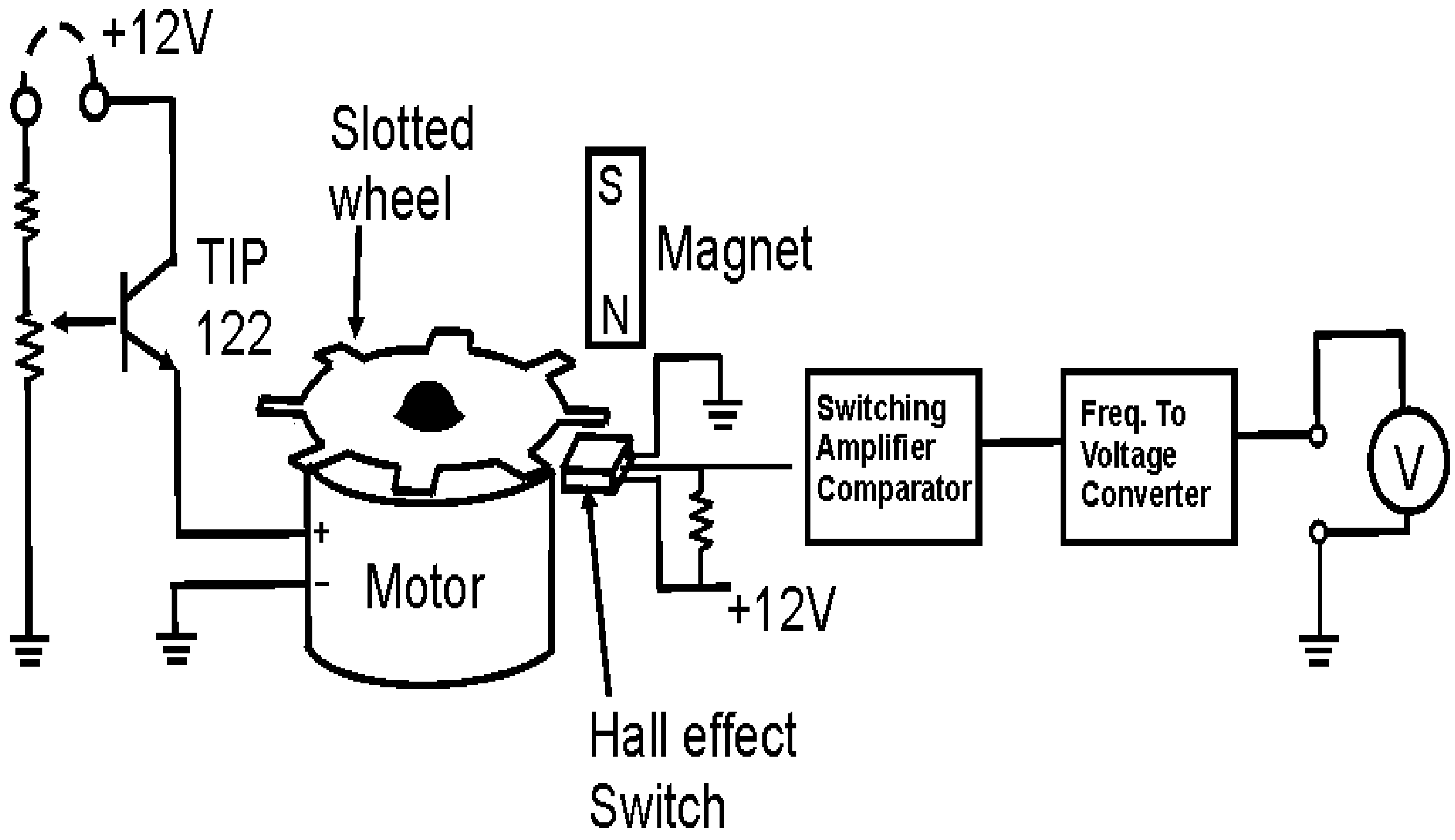
- The DC tachometer generator uses the commutator and brushes which have many disadvantages.
- AC tachometer generator designs for reducing the problems.
- AC tachometer has stationary armature and rotating magnetic field.
- Commutator and brushes are absent in AC tachometer generator.



- The rotating magnetic field induces the EMF in the stationary coil of the stator.
- The amplitude and frequency of the induced emf are equivalent to the speed of the shaft.
- Thus, either amplitude or frequency is used for measuring the angular velocity.
- Circuit shown is used for measuring the speed of the rotor by considering the amplitude of the induced voltage.
- The induces voltages are rectified and then passes to the capacitor filter for smoothening the ripples of rectified voltages.

Hall effect switch for Speed measurement

- On rotation of motor slotted wheel rotates.
- When tooth of wheel appears in between magnet and Hall switch Magnetic field weakens and Hall effect switch output changes its state (becomes high).
- Thus hall effect gives one pulse per tooth of wheel..
- These pulses are amplified and converted into sharp pulses by comparator.
- Further theses pulses are converted into DC voltage by frequency to voltage converter.


+12V
TIP
122
Slotted
wheel
S
N
Magnet
+
-
Motor
+12V
Switching
Amplifier
Comparator
Freq. To
Voltage
Converter
V
Hall effect
Switch